
**Hydraulic fluid power — General rules
and safety requirements for systems and
their components**

*Transmissions hydrauliques — Règles générales et exigences de
sécurité relatives aux systèmes et leurs composants*

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Reference number
ISO 4413:2010(E)

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Published in Switzerland

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 4413 was prepared by Technical Committee ISO/TC 131, *Fluid power systems*, Subcommittee SC 9, *Installations and systems*.

This third edition cancels and replaces the second edition (ISO 4413:1998), which has been technically revised, specifically with regards to the following:

- a) integration of ISO 4413:1998 and EN 982:1996;
- b) integration of safety requirements to comply with the European Machinery Directive 2006/42/EC;
- c) updating of safety requirements, taking into account International Standards on machine safety.

Introduction

This International Standard is a type B standard as defined in ISO 12100. The provisions of this International Standard can be supplemented or modified by a type C standard. For machines that are covered by the scope of a type C standard and that have been designed and built in accordance with the provisions of that standard, the provisions of that type C standard take precedence over the provisions of this type B standard.

In hydraulic fluid power systems, power is transmitted and controlled through a liquid under pressure within an enclosed circuit.

In the past, ISO 4413 was intended to provide assistance in the understanding between the supplier and the purchaser. This edition of ISO 4413 now includes, in addition, general requirements for the engineering of a hydraulic system and safety requirements that support the essential health and safety requirements of the European Machinery Directive.

Equivalent requirements for pneumatic systems are defined in ISO 4414.

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Hydraulic fluid power — General rules and safety requirements for systems and their components

1 Scope

This International Standard specifies general rules and safety requirements for hydraulic fluid power systems and components used on machinery as defined by ISO 12100:2010, 3.1. It deals with all significant hazards associated with hydraulic fluid power systems and specifies the principles to apply in order to avoid those hazards when the systems are put to their intended use.

NOTE 1 See Clause 4 and Annex A.

The significant hazard noise is incompletely dealt with in this International Standard.

NOTE 2 Noise emission depends especially on the installation of hydraulic components or systems into machinery.

This International Standard applies to the design, construction and modification of systems and their components, also taking into account the following aspects:

- a) assembly;
- b) installation;
- c) adjustment;
- d) uninterrupted system operation;
- e) ease and economy of maintenance and cleaning;
- f) reliable operation in all intended uses;
- g) energy efficiency; and
- h) environment.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1219-1, *Fluid power systems and components — Graphic symbols and circuit diagrams — Part 1: Graphic symbols for conventional use and data-processing applications*

ISO 1219-2, *Fluid power systems and components — Graphic symbols and circuit diagrams — Part 2: Circuit diagrams*

ISO 4021, *Hydraulic fluid power — Particulate contamination analysis — Extraction of fluid samples from lines of an operating system*

ISO 4406, *Hydraulic fluid power — Fluids — Method for coding the level of contamination by solid particles*

ISO 5598, *Fluid power systems and components — Vocabulary*

ISO 6149-1, *Connections for hydraulic fluid power and general use — Ports and stud ends with ISO 261 metric threads and O-ring sealing — Part 1: Ports with truncated housing for O-ring seal*

ISO 6149-2, *Connections for hydraulic fluid power and general use — Ports and stud ends with ISO 261 metric threads and O-ring sealing — Part 2: Dimensions, design, test methods and requirements for heavy-duty (S series) stud ends*

ISO 6149-3, *Connections for hydraulic fluid power and general use — Ports and stud ends with ISO 261 metric threads and O-ring sealing — Part 3: Dimensions, design, test methods and requirements for light-duty (L series) stud ends*

ISO 6162-1, *Hydraulic fluid power — Flange connectors with split or one-piece flange clamps and metric or inch screws — Part 1: Flange connectors for use at pressures of 3,5 MPa (35 bar) to 35 MPa (350 bar), DN 13 to DN 127*

ISO 6162-2, *Hydraulic fluid power — Flange connectors with split or one-piece flange clamps and metric or inch screws — Part 2: Flange connectors for use at pressures of 35 MPa (350 bar) to 40 MPa (400 bar), DN 13 to DN 51*

ISO 6164, *Hydraulic fluid power — Four-screw, one-piece square-flange connections for use at pressures of 25 MPa and 40 MPa (250 bar and 400 bar)*

ISO 10763, *Hydraulic fluid power — Plain-end, seamless and welded precision steel tubes — Dimensions and nominal working pressures*

ISO 12100:2010, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

ISO 13850, *Safety of machinery — Emergency stop — Principles for design*

ISO 13851, *Safety of machinery — Two-hand control devices — Functional aspects and design principles*

ISO 16874, *Hydraulic fluid power — Identification of manifold assemblies and their components*

ISO 17165-1, *Hydraulic fluid power — Hose assemblies — Part 1: Dimensions and requirements*

ISO 23309, *Hydraulic fluid power systems — Assembled systems — Methods of cleaning lines by flushing*

IEC 60947-5-5, *Low-voltage switchgear and controlgear — Part 5-5: Control circuit devices and switching elements — Electrical emergency stop device with mechanical latching function*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5598 and ISO 12100 and the following apply.

3.1
function plate
surface that contains information describing either the performance of a manually operated device (e.g. ON/OFF, forward/reverse, left/right, up/down) or the status of a function performed by the system (e.g. clamp, lift, advance)

4 List of significant hazards

Table A.1 lists the significant hazards associated with the use of hydraulic fluid power in a machine.

5 General rules and safety requirements

5.1 General

5.1.1 When designing hydraulic systems for machinery, all intended operations and use of systems shall be considered. Risk assessment, e.g. in accordance with ISO 14121-1, shall be carried out to determine the foreseeable risks associated with systems when they are used as intended. Reasonably foreseeable misuse shall not cause hazards. The risks identified shall be eliminated by design and, where this is not practicable, safeguards (first preference) or warnings (second preference) against such risks shall be incorporated, in accordance with the hierarchy established in ISO 12100.

NOTE This International Standard provides requirements for components of fluid power systems; some of these requirements are dependent on the hazards associated with the machine in which the system is installed. Therefore, the final specification and construction of the hydraulic system could need to be based on risk assessment and agreement between purchaser and supplier.

5.1.2 The control systems shall be designed in accordance with the risk assessment. This requirement is met when ISO 13849-1 is used.

5.1.3 The prevention of damage to the machine, system and the environment shall be considered.

5.2 Basic requirements for the design and specification of hydraulic systems

5.2.1 Selection of components and piping

5.2.1.1 All components and piping in the system shall be selected or specified to provide for safety in use, and they shall operate within their rated limits when the system is put to its intended use. Components and piping shall be selected or specified so as to ensure that they can operate reliably under all intended uses of the system. Particular attention shall be paid to the reliability of components and piping that can cause a hazard in the event of their failure or malfunction.

5.2.1.2 Components and piping shall be selected, applied and installed in accordance with the supplier's instructions and recommendations, unless testing or field experience validates other components, applications or installations. Operator manuals for mobile machinery may exclude operation in certain situations.

5.2.1.3 It is recommended that, wherever practicable, components and piping made in conformance with recognized International Standards be used.

5.2.2 Unintended pressures

5.2.2.1 All related parts of the system shall be designed or otherwise protected against foreseeable pressures exceeding the maximum working pressure of a system or the rated pressure of any part of the system if the excessive pressure can cause a hazard.

Any system or part of a system that can be disconnected and sealed so that trapped fluid can be subject to a pressure increase or decrease (e.g. due to the change in a load or the fluid temperature) shall include means for limiting the pressure if the change can cause a hazard.

5.2.2.2 The preferred means of protection against excessive pressure is one or more pressure-relief valves located to limit the pressure in all related parts of the system. Other means, such as pressure-compensator pump controls, may be used to limit main system operating pressure, provided these means ensure safety under all operating conditions.

5.2.2.3 Systems shall be designed, constructed and adjusted to limit pressure surges and fluctuations. Pressure surges and fluctuations shall not cause hazards.

5.2.2.4 Loss of pressure or pressure drop shall not expose persons to a hazard and should not damage the machinery.

5.2.2.5 Means shall be provided to prevent unacceptable pressure build-up where high external loads are reflected on actuators.

5.2.3 Mechanical movements

In stationary industrial machinery, mechanical movements, whether intended or unintended (e.g. effects from acceleration, deceleration or lifting/holding of masses), shall not result in a situation hazardous to persons.

5.2.4 Noise

In the design of hydraulic systems, the expected noise shall be taken into account, and noise generation shall be minimized at its source. Depending on the application, measures shall be taken to minimize the risks caused by noise. Airborne, structure-borne and liquid-borne noise shall be considered.

NOTE For the design of low-noise machinery and systems, see ISO/TR 11688-1.

5.2.5 Leakage

If leakage (internal or external) occurs, it shall not cause a hazard.

5.2.6 Temperature

5.2.6.1 Operating temperature

The full range of operating temperatures for the system or any component shall not exceed the specified limits at which they can safely be used.

5.2.6.2 Surface temperature

Hydraulic systems shall be designed to protect persons from surface temperatures that exceed touchable limits by either location or guarding; see ISO 13732-1. When such protection is not possible, proper warnings shall be provided.

5.2.7 Operational and functional requirements for hydraulic systems

The following specifications for operation and function shall be defined:

- a) working pressure range;
- b) working temperature range;
- c) type of fluid being used;
- d) working flow-rate range;
- e) lifting provisions;
- f) emergency, safety and energy isolation requirements;
- g) painting or protective coating.

Annex B (informative) provides forms and checklists to facilitate the gathering and recording of this information for stationary machinery. These forms and checklists may also be useful to record those specifications that apply to hydraulic systems used in mobile machinery.

5.3 Additional requirements

5.3.1 Site conditions and operating environment

Site conditions and operating environment that affect the requirements of hydraulic systems used in stationary industrial machinery shall be defined. Annex B (informative) provides forms and checklists to facilitate the gathering and recording of this information, which may include:

- a) ambient temperature range of the installation;
- b) humidity range of the installation;
- c) available utilities, e.g. electricity, water, waste;
- d) electrical network details, e.g. voltage and its tolerance; frequency, available power (if limited);
- e) protection for electrical circuits and devices;
- f) atmospheric pressure;
- g) sources of contamination;
- h) sources of vibration;
- i) possible severity of a fire, explosion or other hazard and availability of related emergency resources;
- j) required reserves, e.g. flow, pressure and volume;
- k) space for access, maintenance and use, as well as the location and mounting of components and hydraulic systems to ensure their stability and security in use;
- l) available cooling and heating media and capacities;
- m) requirements for the protection of persons and the hydraulic system and its components;
- n) legal and environmental limiting factors;
- o) other safety requirements.

Annex B may also be useful to record those environmental conditions that apply to the specification of a hydraulic system used in mobile machinery. The individual forms in Annex B are also available in a separate revisable electronic format.

5.3.2 Installation, use and maintenance of components, piping and assemblies

5.3.2.1 Replacement

To facilitate maintenance, means should be provided or components and piping fitted so that their removal from the system for maintenance

- a) minimizes the loss of fluid;
- b) for stationary machinery only, does not require the draining of the reservoir;
- c) does not necessitate an otherwise needless disassembly of adjacent parts.

5.3.2.2 Maintenance requirements

The system shall be designed and constructed so that components and piping that require adjustment or maintenance are located where they are accessible and can be safely adjusted and serviced. Where these requirements are not feasible, maintenance and service information shall be provided; see 7.3.1.1 g) and n).

5.3.2.3 Lifting provisions

All components, assemblies or piping having a mass greater than 15 kg should have provision(s) for lifting by means of lifting devices.

5.3.2.4 Installation

Components should be installed so that they are accessible from a safe working position (for example, ground-level or working platform).

5.3.2.5 Use of standard parts

5.3.2.5.1 Commercially available parts (keys, bearings, packings, seals, washers, plugs, fasteners, etc.) and part configurations (shaft and spline sizes, port sizes, mountings, mounting surfaces or cavities, etc.) should be selected and coded in accordance with accepted International Standards.

5.3.2.5.2 Within a hydraulic system, ports, studs, and connectors should be limited to the minimum number of standard series possible. All port connections should be in accordance with ISO 6149-1, ISO 6149-2 and ISO 6149-3 for threaded port connections, or ISO 6162-1, ISO 6162-2 or ISO 6164 for four-screw flange port connections.

NOTE When using more than one type of ISO standard threaded port connection [e.g. ISO 1179 (all parts), ISO 9974 (all parts) and ISO 11926 (all parts)] in a system, there is a strong possibility of incompatible intermixing between some stud ends from one connection series and some ports from a different connection series, causing leakage and severe failure of the connection system. Ports and stud ends that conform to ISO 6149-1, ISO 6149-2 and ISO 6149-3 are marked such that they are identifiable.

5.3.2.6 Seals and sealing devices

5.3.2.6.1 Materials

Seal and sealing device materials shall be compatible with the fluid used, adjacent materials and their working conditions and environment.

5.3.2.6.2 Replacement

Component design shall facilitate servicing and replacement of seals and sealing devices, if such servicing and replacement is intended.

5.3.3 Cleaning and painting

5.3.3.1 During external cleaning and painting of machinery, sensitive materials shall be protected from incompatible liquids.

5.3.3.2 During painting, areas that should not be painted (e.g. piston rods, indicator lights) shall be covered and the coverings removed afterwards. After painting, all warnings and safety-related markings shall be visible and legible.

5.3.4 Preparation for transportation

5.3.4.1 Identification of piping

Whenever it is necessary to dismantle hydraulic systems for transportation and where an incorrect reconnection can cause a hazard, the piping and corresponding connections shall be clearly identified. The identification shall correspond to the data on all appropriate documentation.

5.3.4.2 Packaging

All parts of the hydraulic system shall be packaged for transportation in a manner that preserves their identification and protects them from damage, distortion, contamination and corrosion.

5.3.4.3 Sealing and protection of openings

Exposed openings in hydraulic systems and components, in particular tubes and hoses, shall be protected during transportation either by being sealed or stored in an appropriately clean and closed container. Male threads shall be protected. Any protective device used shall be of the type that prevents reassembly until it is removed.

5.3.4.4 Handling facilities

Transport sizes and masses shall be consistent with the handling facilities available at the purchaser's premises (e.g. lifting tackle, passageways, ground loading); see B.1.5. If necessary, the hydraulic system shall be designed such that it can be easily disassembled into subassemblies.

5.4 Specific requirements for components and controls

5.4.1 Pumps and motors

5.4.1.1 Mounting

Hydraulic pumps and motors shall be mounted or installed so that

- a) they are accessible for maintenance;
- b) no shaft misalignment is introduced as a result of the duty cycle, temperature variations or applied weight loadings;
- c) induced axial and radial loads are within rated limits for the pumps and motors and any drive components used;
- d) all fluid connections are correctly connected; all pump shafts rotate in the correct direction as marked and intended; all pumps deliver fluid from inlet to discharge; and all motor shafts rotate in the correct direction relative to the direction of fluid flow;
- e) vibration is adequately damped.

5.4.1.2 Couplings and mountings

5.4.1.2.1 Drive couplings and mountings shall be capable of continuously withstanding the maximum torque that can be generated at the pump or motor under all conditions of intended use.

5.4.1.2.2 Drive couplings shall be provided with a suitable protective guard when the coupling area can be accessible during operation of the pump or motor.

5.4.1.3 Rotational speed

Rotational speed shall not exceed the specified limits.

5.4.1.4 Drains, air bleeds and auxiliary ports

Drains, air bleeds and similar auxiliary ports shall be installed so that they do not allow ingress of air into the system. They shall be designed and installed such that back pressure does not exceed the pump or motor manufacturer's recommendations. If high-pressure air bleeds are used, they shall be installed so as to minimize the hazard to persons.

5.4.1.5 Pre-filling of housings

Where the housings of hydraulic pumps and motors require pre-filling with fluid prior to start up, a readily accessible and marked means for pre-filling shall be provided and be located to ensure that air is not trapped in the housings.

5.4.1.6 Working pressure range

If there are any restrictions on the working pressure range at which the pump or motor may be used, these shall be defined in the technical data; see Clause 7.

5.4.1.7 Installation

Hydraulic pumps and motors shall be installed so that

- a) through the arrangement and selection of piping connections external leakage is prevented; tapered pipe threads or connection mechanisms that require sealing compounds shall not be used;
- b) loss of prime or case lubrication is prevented during periods of inactivity;
- c) pressure at the pump inlet port is not less than the minimum specified by the pump supplier for the operating conditions and the system fluid used;
- d) they are either protected from predictable external damage, or suitably guarded if a hazard results.

5.4.2 Cylinders

5.4.2.1 Resistance to buckling

Attention shall be given to stroke length, loading and cylinder mountings in order to avoid bending or buckling of the cylinder piston rod at any position; see ISO/TS 13725.

5.4.2.2 Dimensioning

The design of cylinders shall take account of the maximum loads and pressure peaks that are expected.

5.4.2.3 Mounting ratings

All load ratings shall take account of the mounting types.

NOTE Cylinder rated pressures reflect only the capability of the pressure-containing envelope and not the force transmitting capability of mounting configurations.

5.4.2.4 Loading by position stop

When a cylinder is used as a position stop, the cylinder shall be sized and the mounting selected on the basis of the maximum loading induced by the machine member restrained.

5.4.2.5 Resistance to shock and vibration

Any attachment mounted on or connected to a cylinder shall be assembled in such a way that resists loosening caused by shock, vibration, etc., while in use.

5.4.2.6 Unintended pressure intensifications

Means shall be provided in the system for preventing unintended pressure intensifications caused by differences in effective cylinder areas from exceeding rated pressure limits.

5.4.2.7 Mounting and alignment

Cylinders should preferably be mounted so that load reaction occurs along the cylinder centreline. The mounting shall minimize the following:

- a) excessive deformation of the cylinder structure from either push or pull loading;
- b) application of side or bending loads;
- c) rotational velocities of cylinder pivot mountings that can necessitate continuous external lubrication.

5.4.2.8 Mounting location

Mounting surfaces shall not distort cylinders, and allowance shall be made for thermal expansion. Cylinders shall be mounted to enable ease of access for maintenance, adjustment to cushioning devices and complete unit replacement.

5.4.2.9 Mounting fasteners

Mounting fasteners for cylinders and accessories shall be designed and installed to accommodate all predictable forces. Foot-mounted cylinders can impose a shear force on the cylinder mounting bolts. If this shear load is of concern, cylinders that have a means to absorb the shear load should be considered. The mounting fasteners shall be adequate to absorb the turning moments.

5.4.2.10 Cushions and deceleration devices

When internal cushioning is used, the cylinder shall be designed to take into account the effects of load deceleration.

5.4.2.11 Adjustable stroke end stops

Means shall be provided to prevent loosening of adjustable external or internal stroke end stops.

5.4.2.12 Piston stroke

The stroke lengths, including tolerances, if not specified in the relevant International Standard, shall be specified, depending on the application of the hydraulic system.

NOTE ISO 6020-1, ISO 6020-2, ISO 6020-3, ISO 6022 and ISO 16656 specify tolerances on stroke lengths.